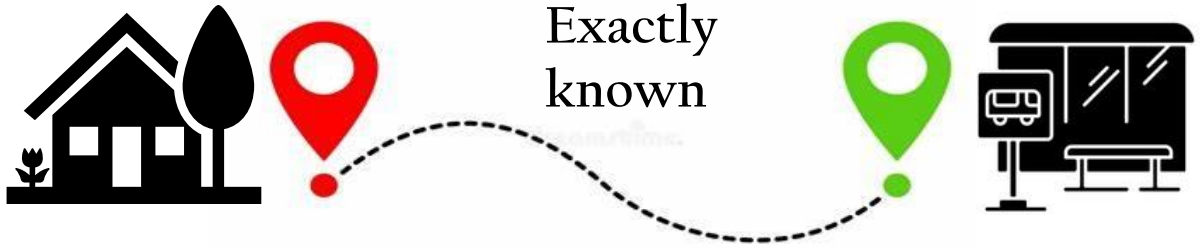
Why we should always use probabilistic forecasting

Josselin LE GAL LA SALLE

21/08/2023

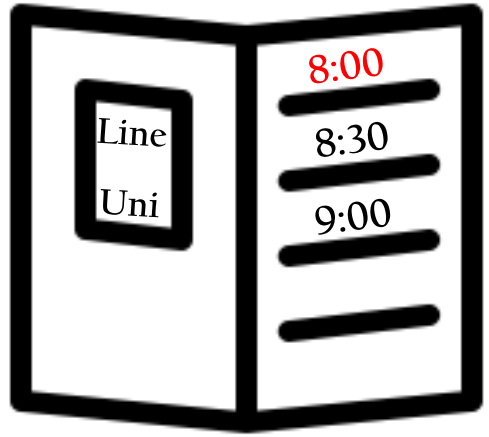


When do you plan to arrive at the bus stop ?

7:45 ? 8:00 ?

7:50 ? 8:05 ?

7:55 ? 8:10 ?



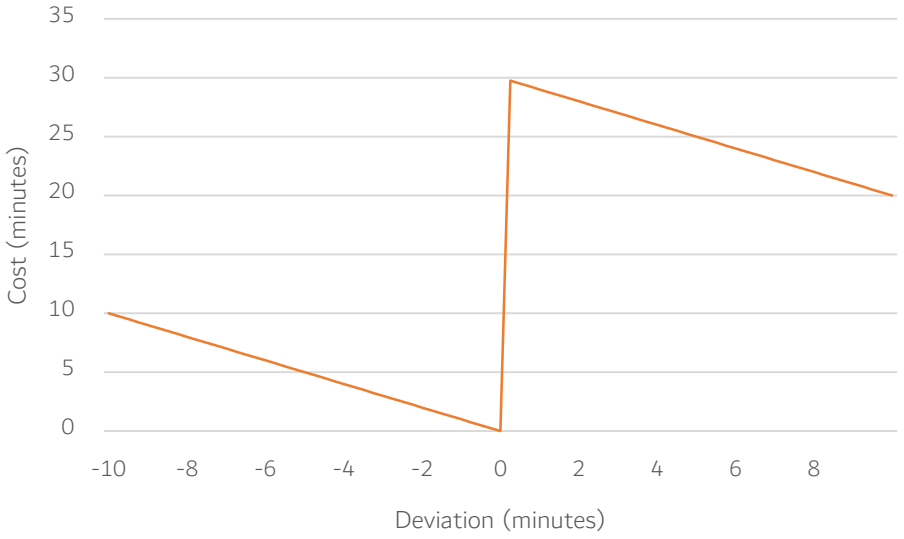
1 Go to wooclap.com

2 Enter the event code in the top banner

Event code
CMUDRB

1 Send @CMUDRB to 06 44 60 96 62

2 You can participate



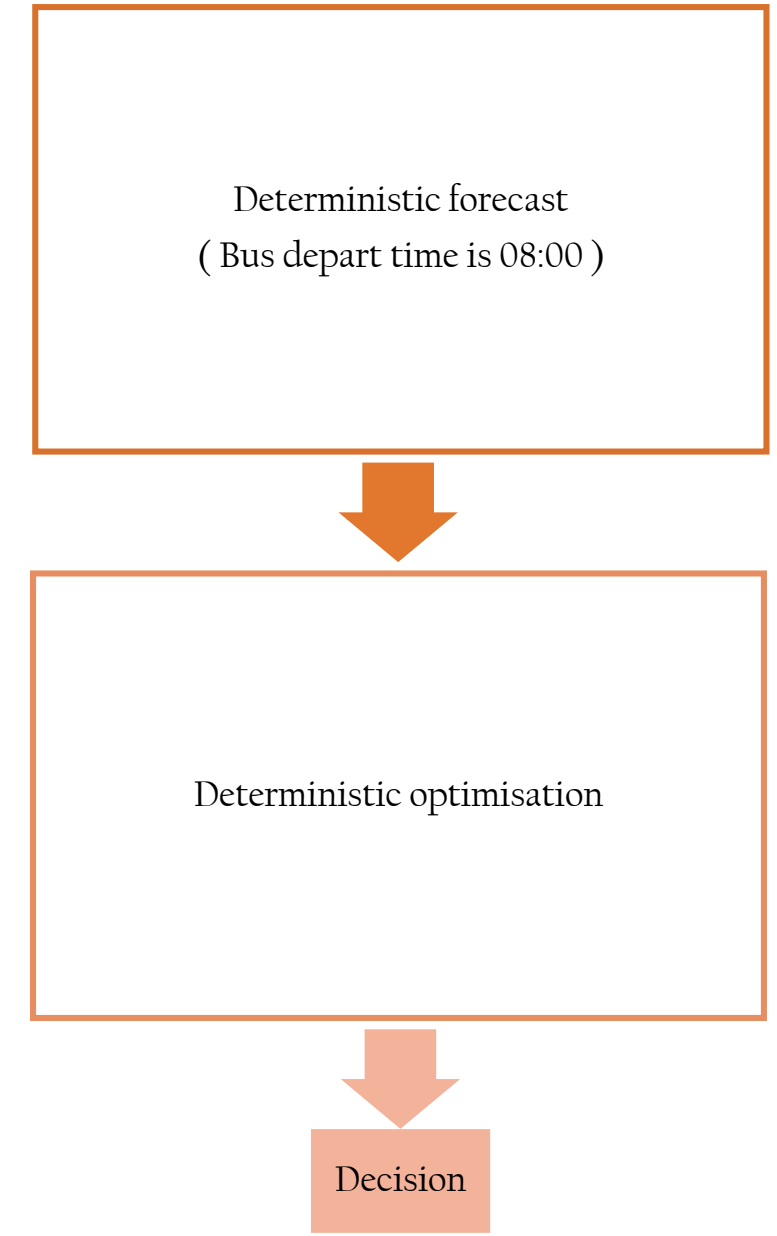
$$Deviation = Bus\ depart\ time\ - Arriving\ time\ bus\ stop$$

How can we optimize the decision ?

1. The cost function should be minimized
2. Minimal cost for a deviation of 0 minute
3. The bus will leave at 8:00 (information from forecast)
4. You need to arrive at the stop at 08:00

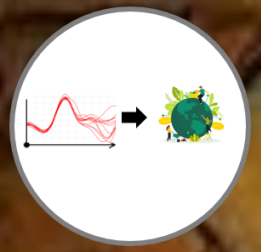
→ Cost = 0 minute

Deterministic decision-making process

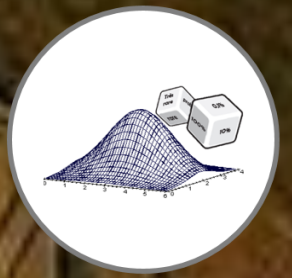


Are you Ready For Explorations?

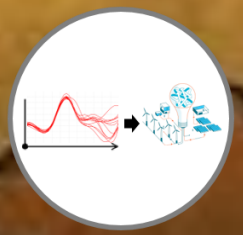
On the value of probabilistic forecasting

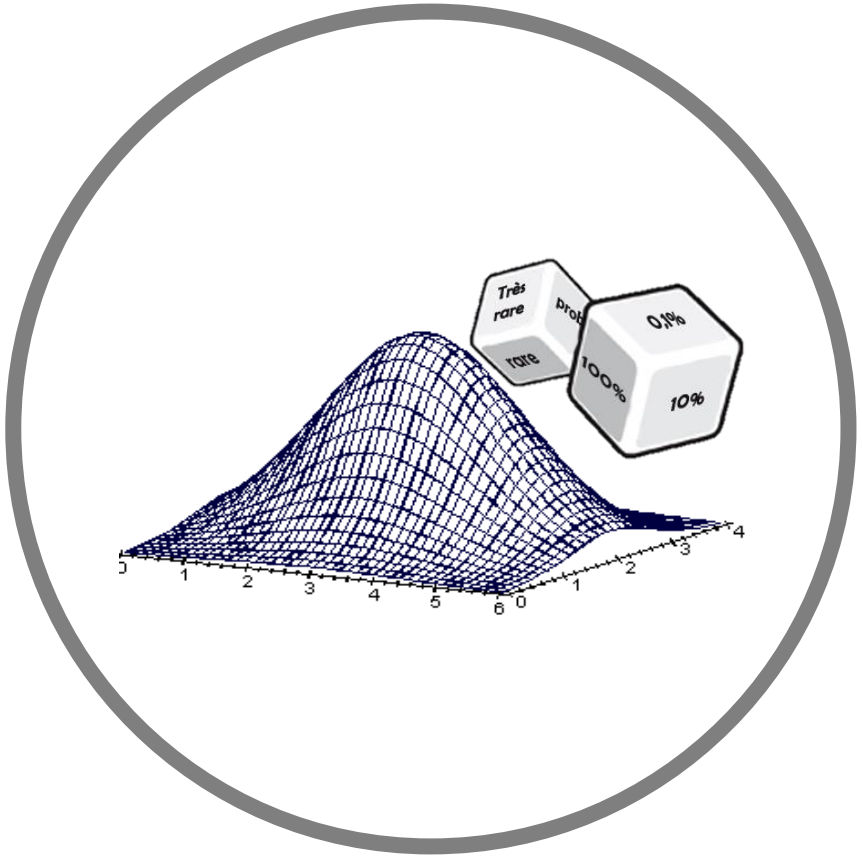


The Probabilistic approach

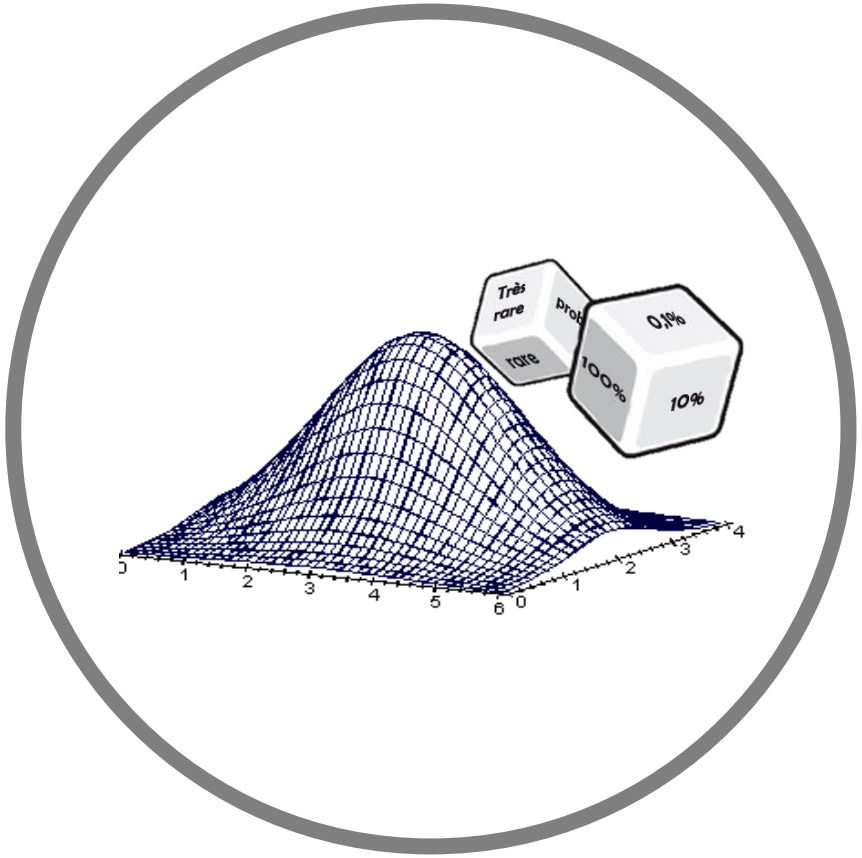


Applications for energy systems management

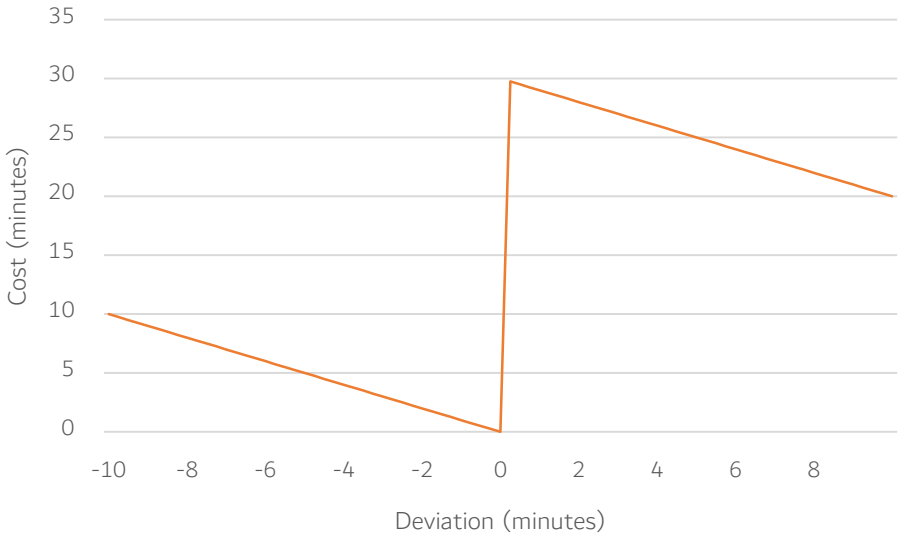


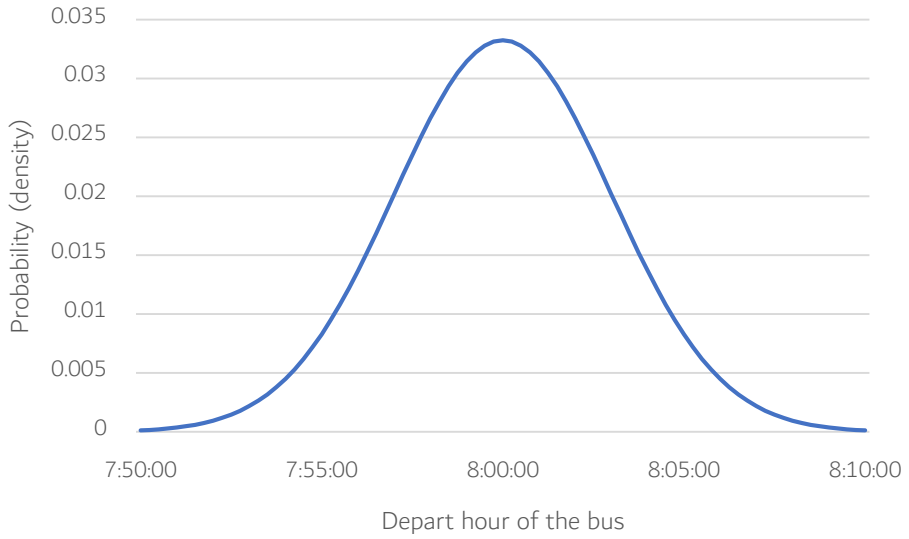

Très rare
rare
100%
0%
10%
0
1
2
3
4
5
6
0
1
2
3
4

The probabilistic approach



The probabilistic approach

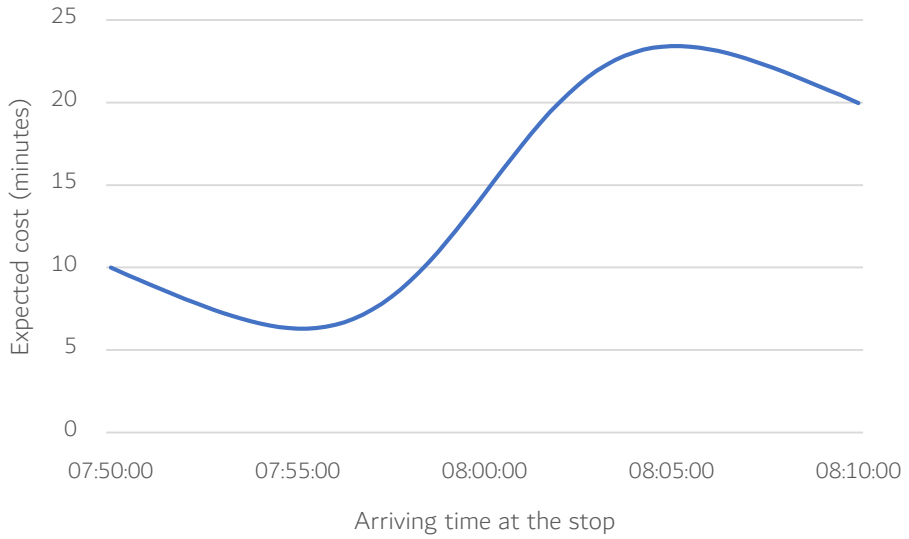




What if the traveler arrives at 8:00 ?

$$Expected\ cost = \int Cost(Deviation) \times P(Deviation = x)dx$$

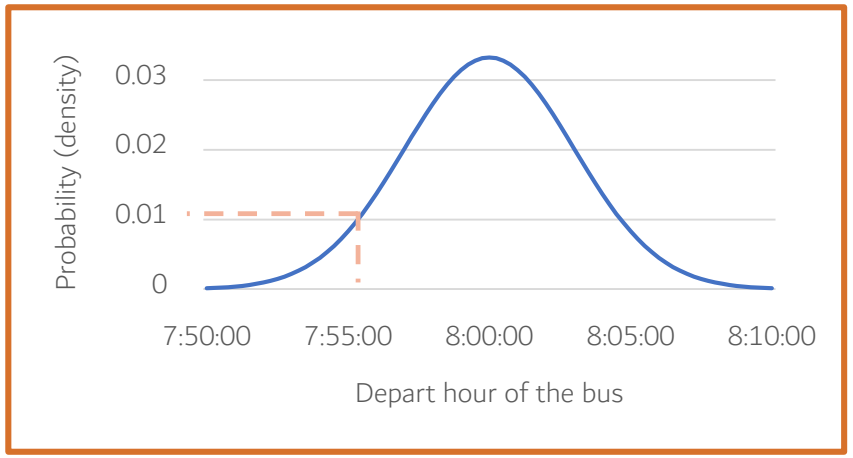
Expected cost (8:00) = 14'30"



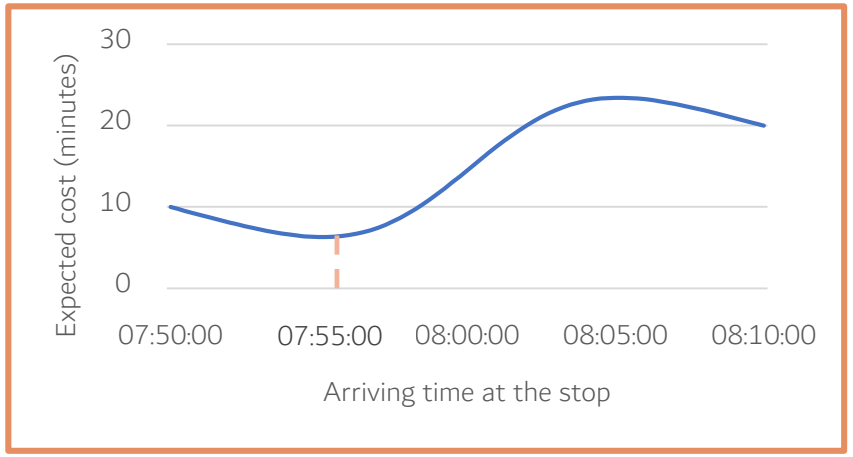
The probabilistic approach

The probabilistic decision-making process

Probabilistic forecast



Probabilistic optimisation

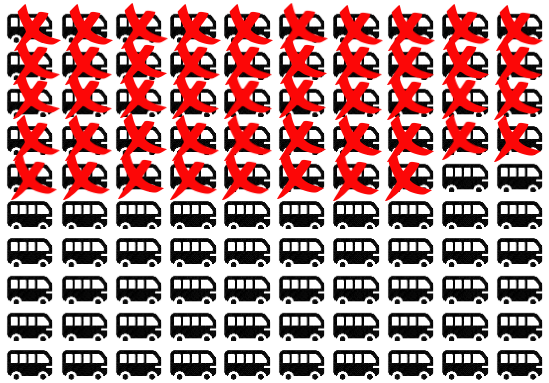


Decision

The probabilistic approach

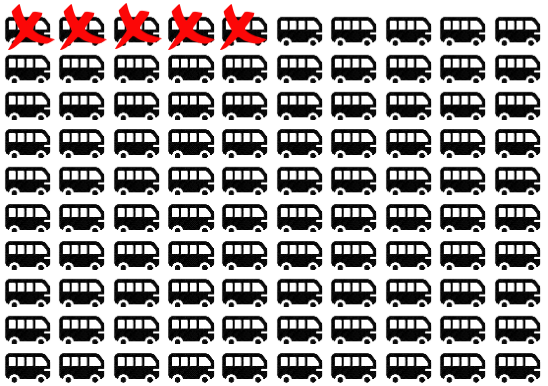
What is the impact on real life ?

Deterministic optimisation
The naive traveler



Average waiting time	Missed buses	Annual waiting time
2'19"	176	88 hours

Probabilistic optimisation
The smart traveller



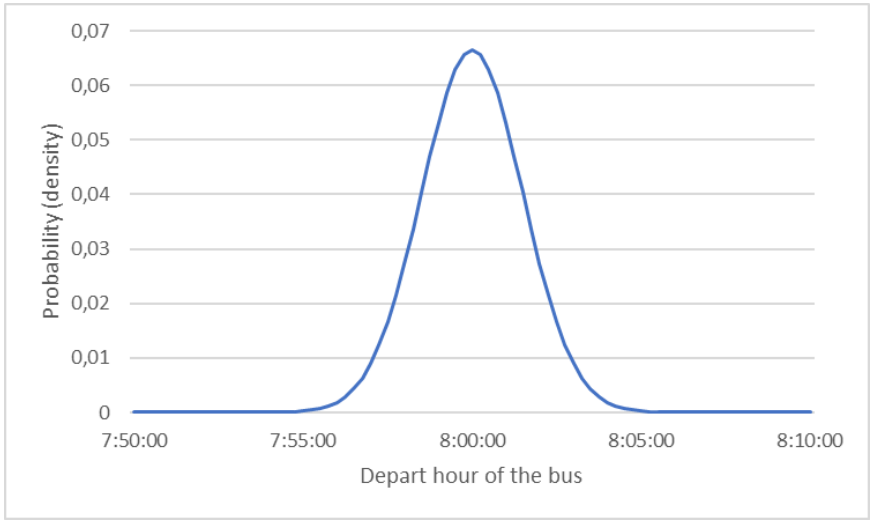
Average waiting time	Missed buses	Annual waiting time
5'17"	19	38 hours

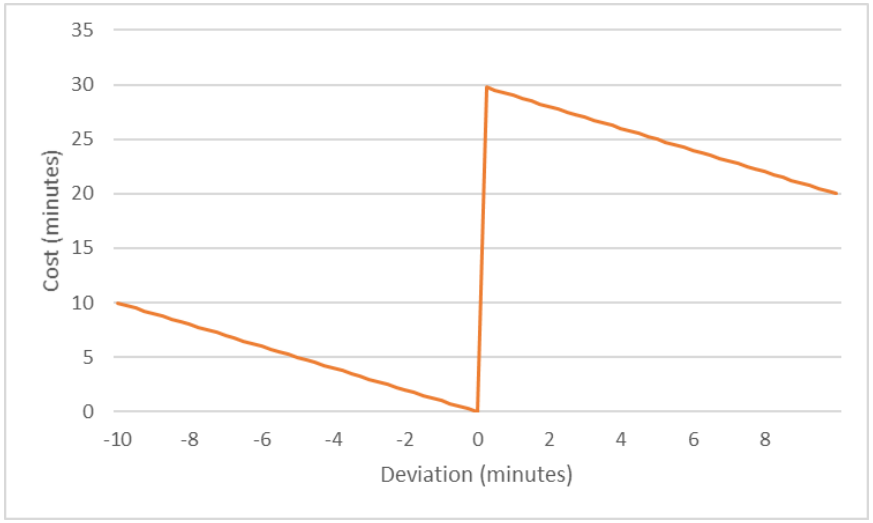
The deterministic prediction provides **one single information** (the most probable outcome), it is just **not the information needed** for proper optimisation !!!

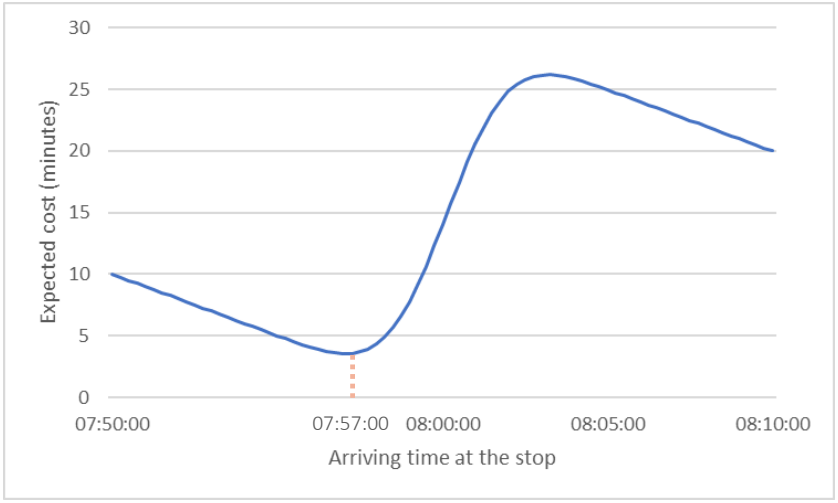
The probabilistic approach

The importance of the variance

What if the variance of the probability distribution changes ?

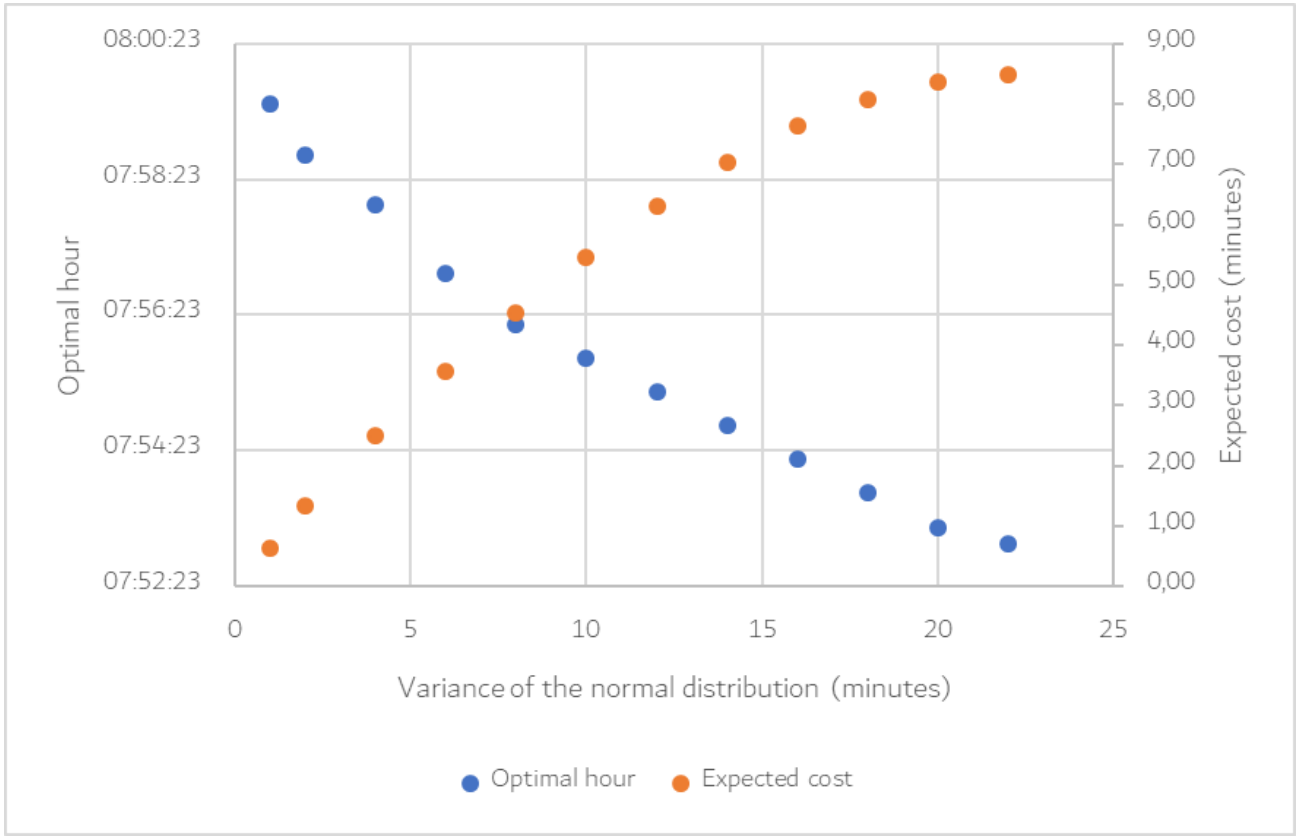


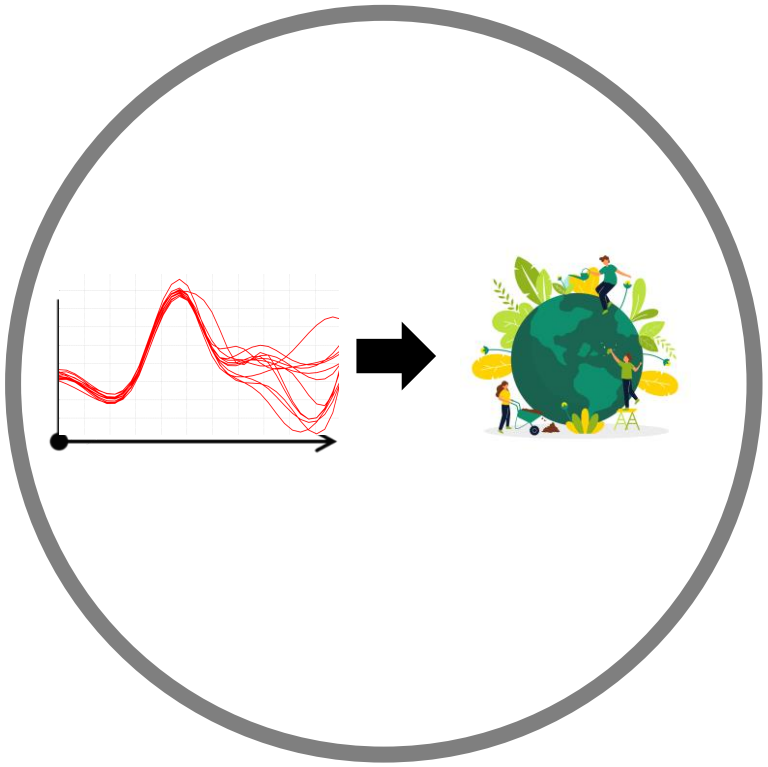


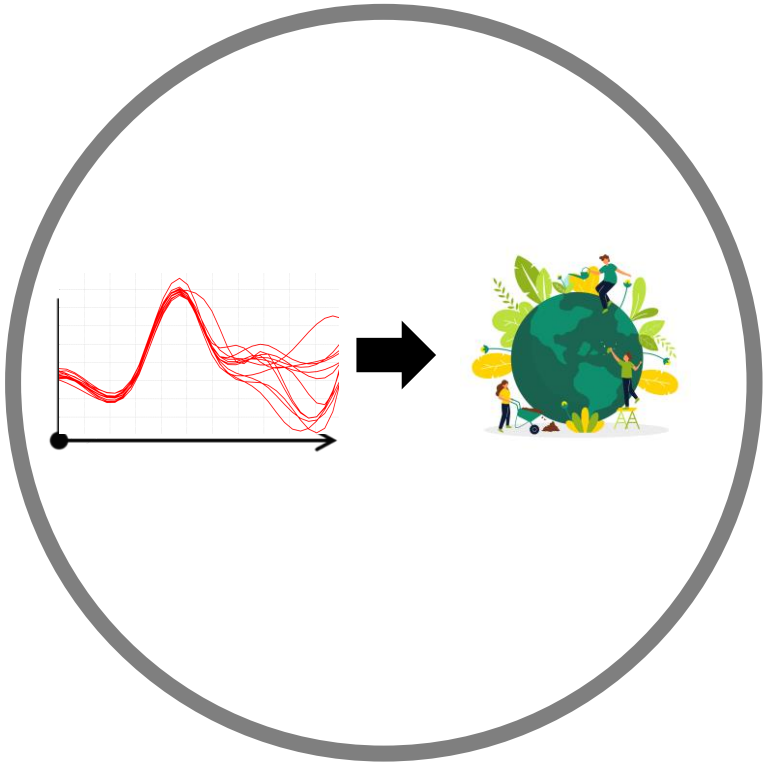


The probabilistic approach

The importance of the variance







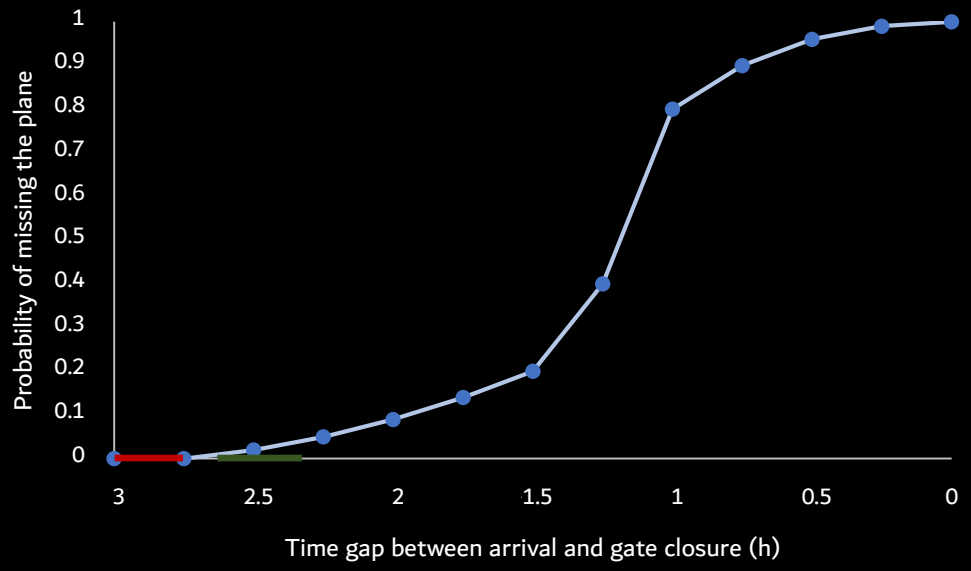
On the value of probabilistic forecasting

On the value of probabilistic forecasting

« If you never miss a plane, you're spending too much time at the airport »
George Stigler, Nobel Prize in Economic Sciences (1982)

On the value of probabilistic forecasting

« If you never miss a plane, you're spending too much time at the airport »
George Stigler, Nobel Prize in Economic Sciences (1982)



On the value of probabilistic forecasting

A cultural parenthesis

Taken from *Lock, Stock and Two Smoking Barrels*, 1998

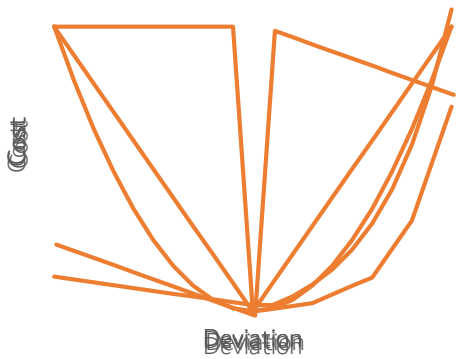
On the value of probabilistic forecasting

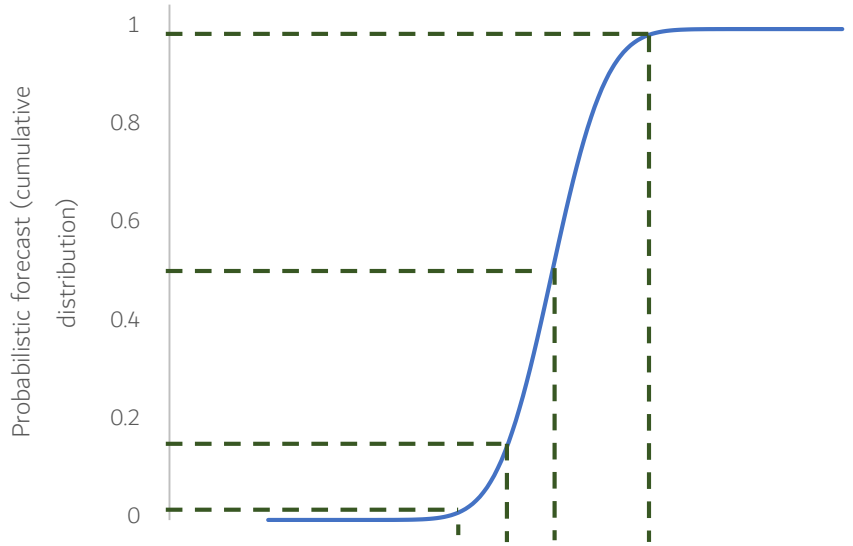
A cultural parenthesis

The right question is :

« Is the probability of winning the race higher or lower than 1% ? »

On the value of probabilistic forecasting

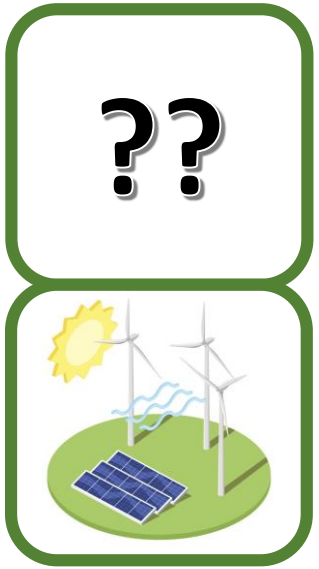


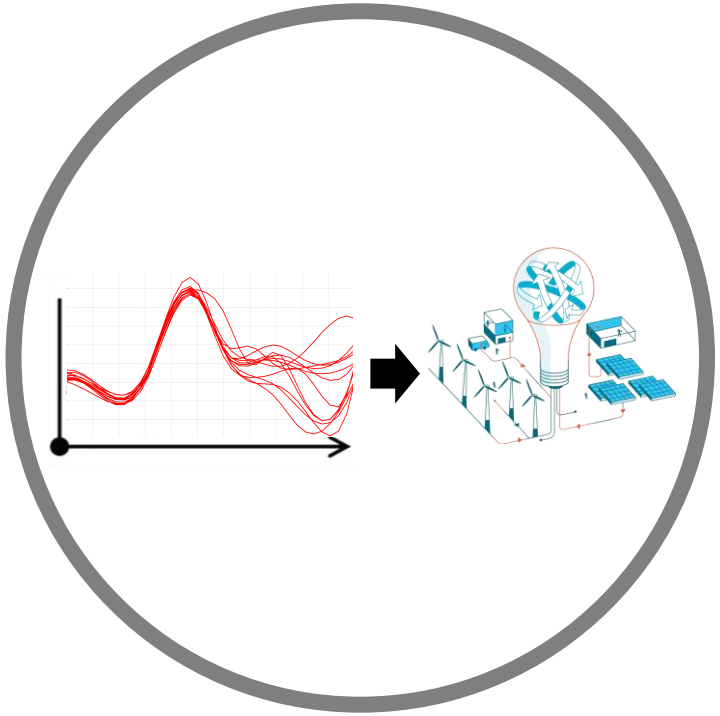


Deterministic optimisation = Probabilistic optimisation ; Deterministic forecast OK
Problem
Typical Loss Function

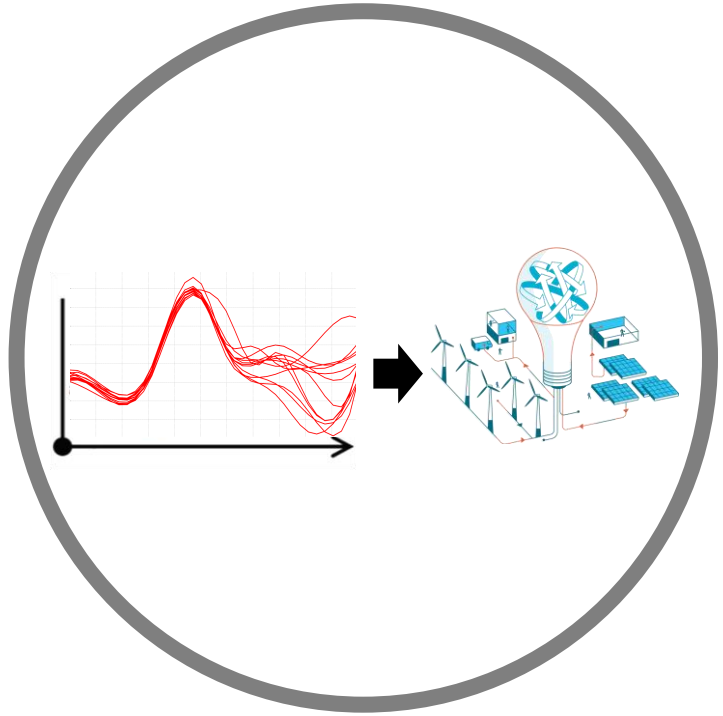
Deterministic optimisation ≠ Probabilistic optimisation ; Deterministic forecast insufficient
Problem
Typical Loss Function

On the value of probabilistic forecasting





Applications for energy systems management



Applications for energy systems management

The CRE ZNI 2015 program

General rules :

- Production of solar electrivity on the distribution network
- Powerplant with storage

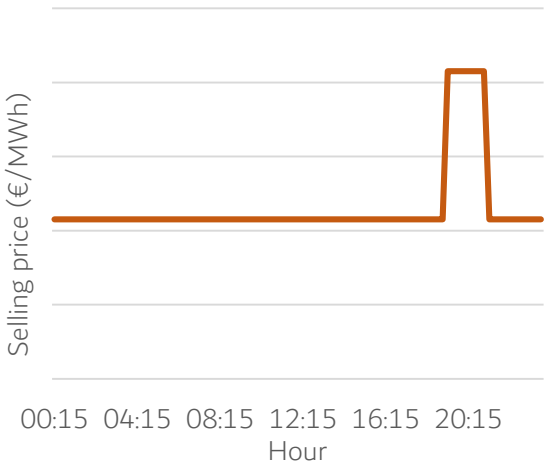
Specific rules :

- Obligation (and incitation) for supply during evening time (19h-21h)
- Obligation of programmation

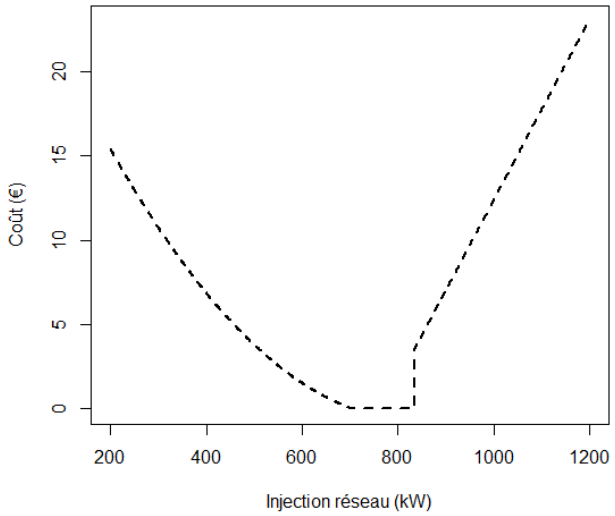
Fictive photovoltaic powerplant

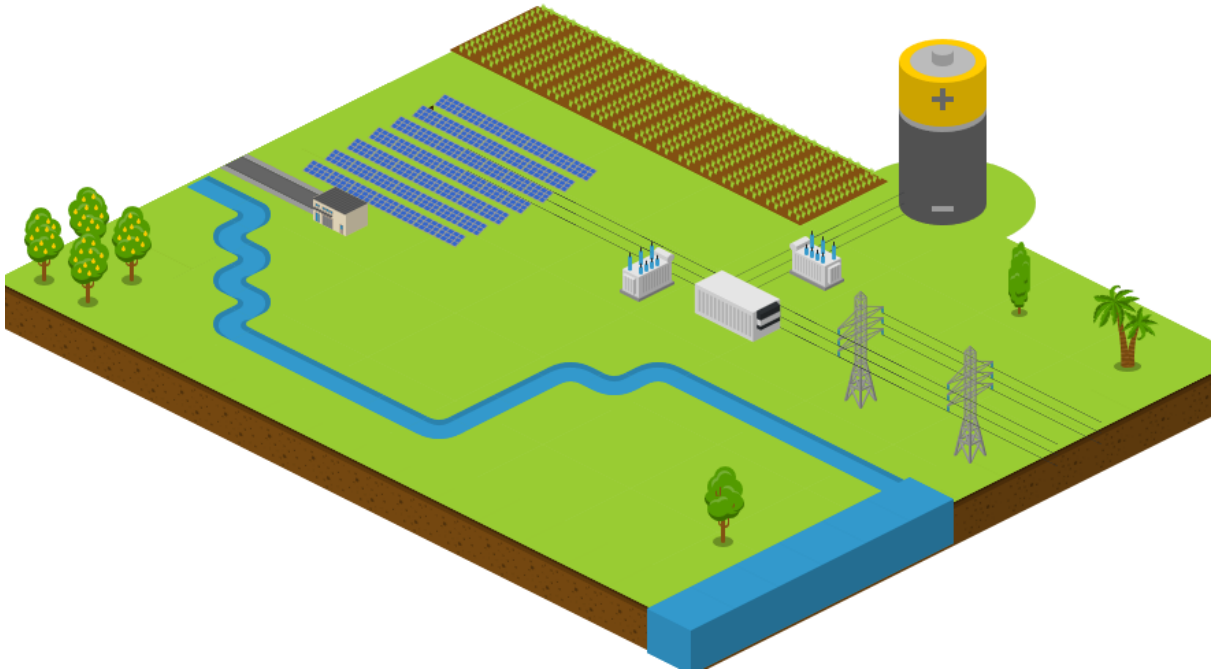
- Installed power : Pc = 1 MWc
- Electrochimical lithium-ion storage : 1 MWh capacity
- Contract price : 215 €/MWh

Incomes



Penalties

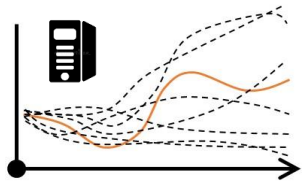




Applications for energy systems management

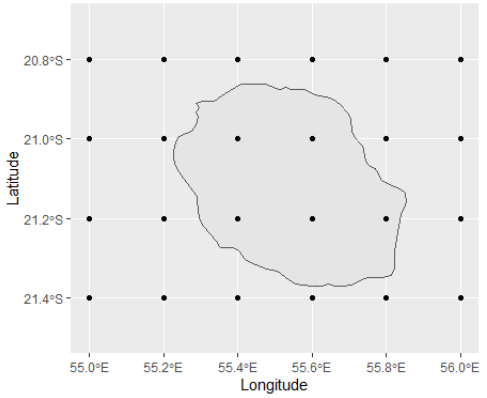
Building probabilistic forecasts

Ensemble forecasts (NWP)



- One « **reference** » simulation and several « **perturbed** » simulations
- The **dispersion** of the trajectories reflects **uncertainty**
- Time calculation increases

Spatial resolution on the island of La Réunion :

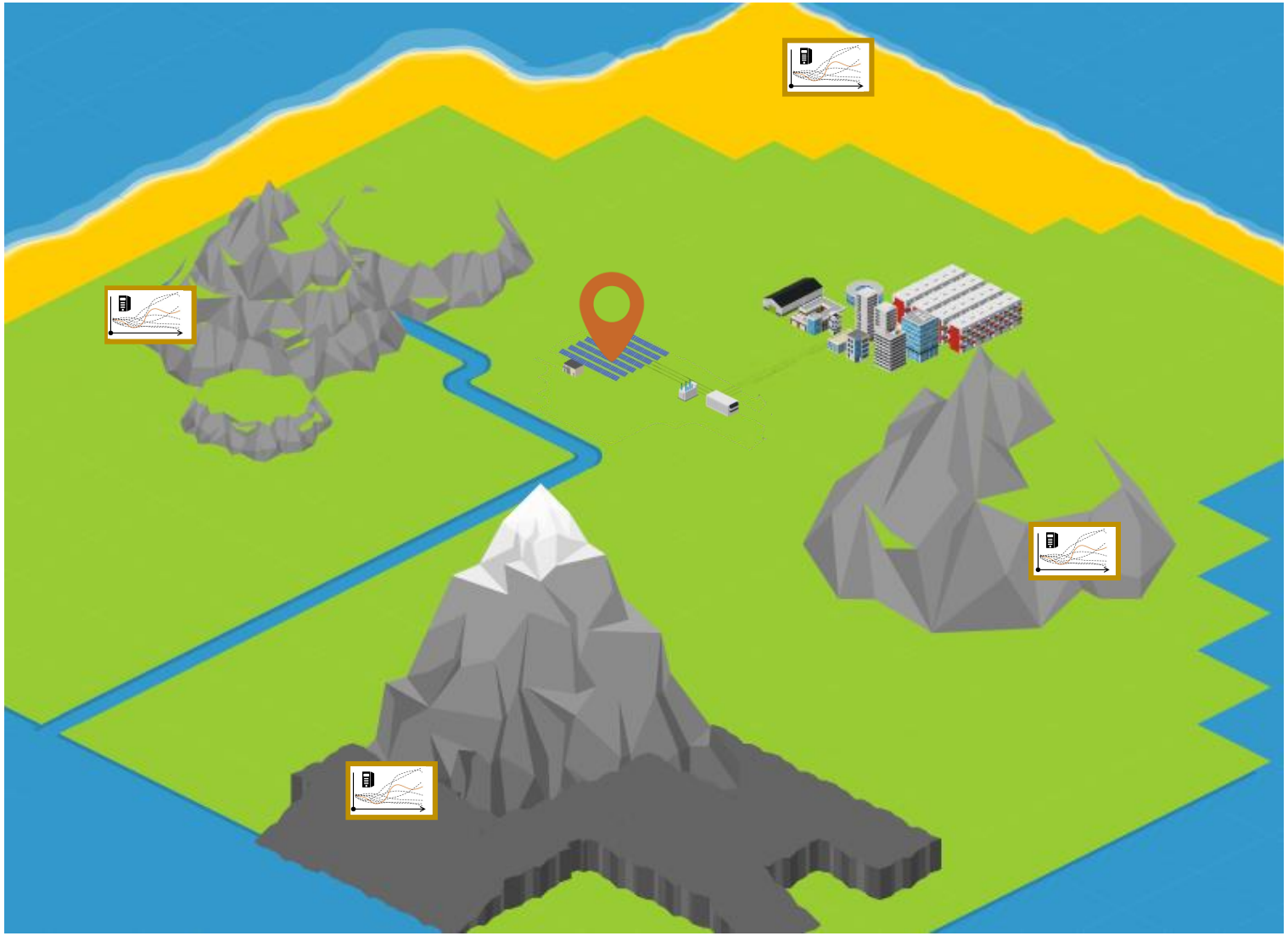


Applications for energy systems management

Building probabilistic forecasts

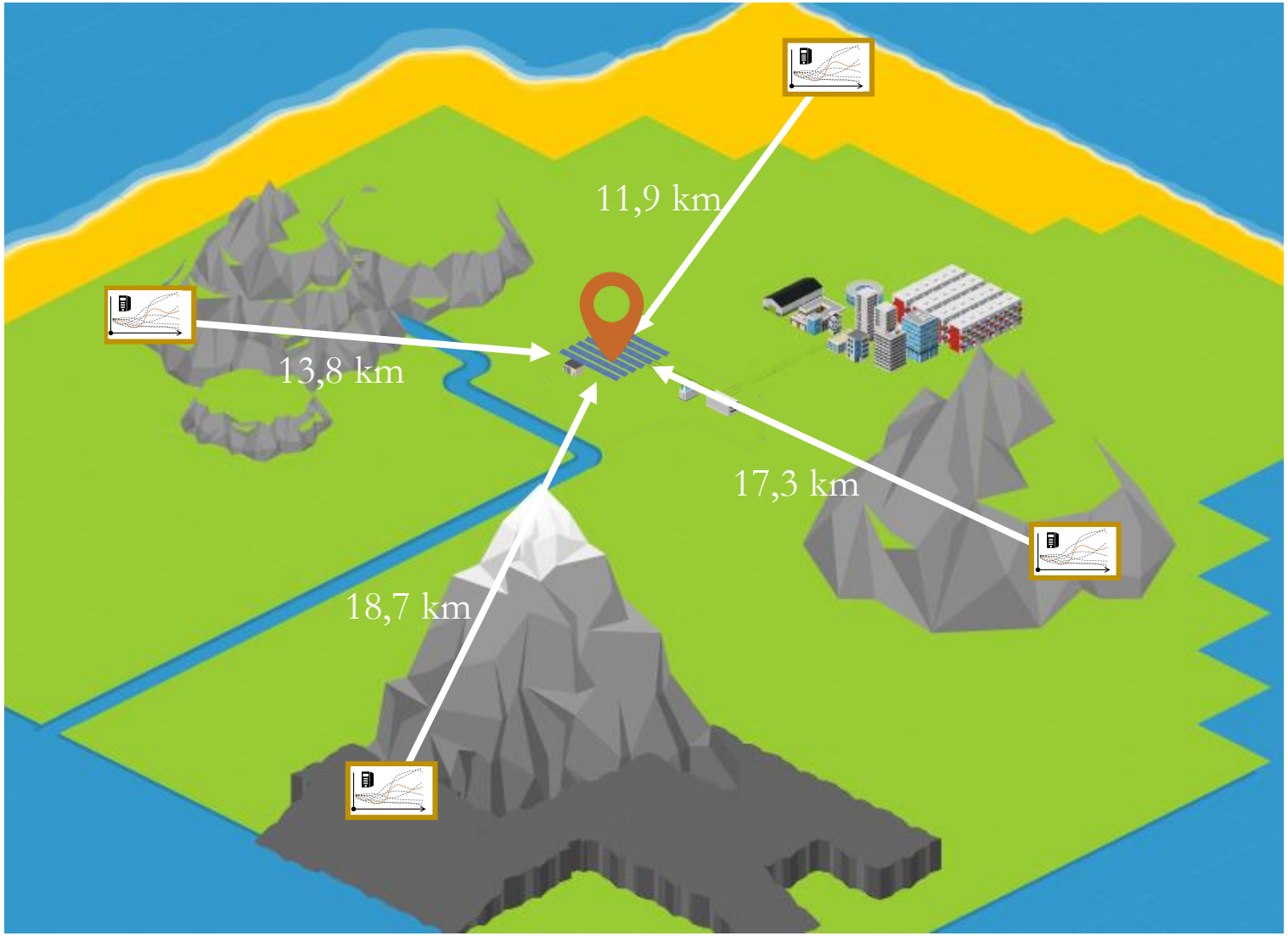
Applications for energy systems management

Building probabilistic forecasts



Applications for energy systems management

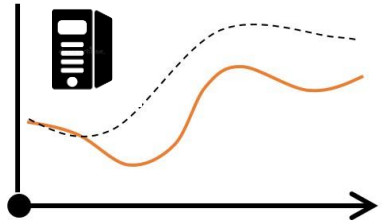
Building probabilistic forecasts



Applications for energy systems management

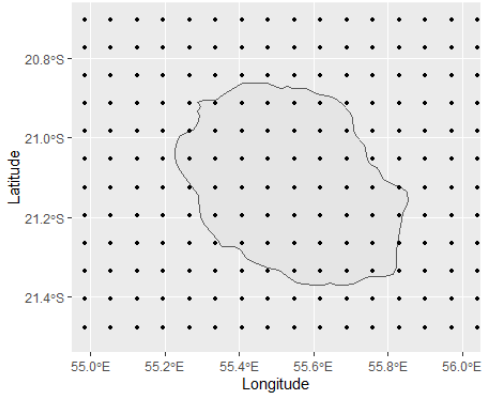
Building probabilistic forecasts

HRES forecasts



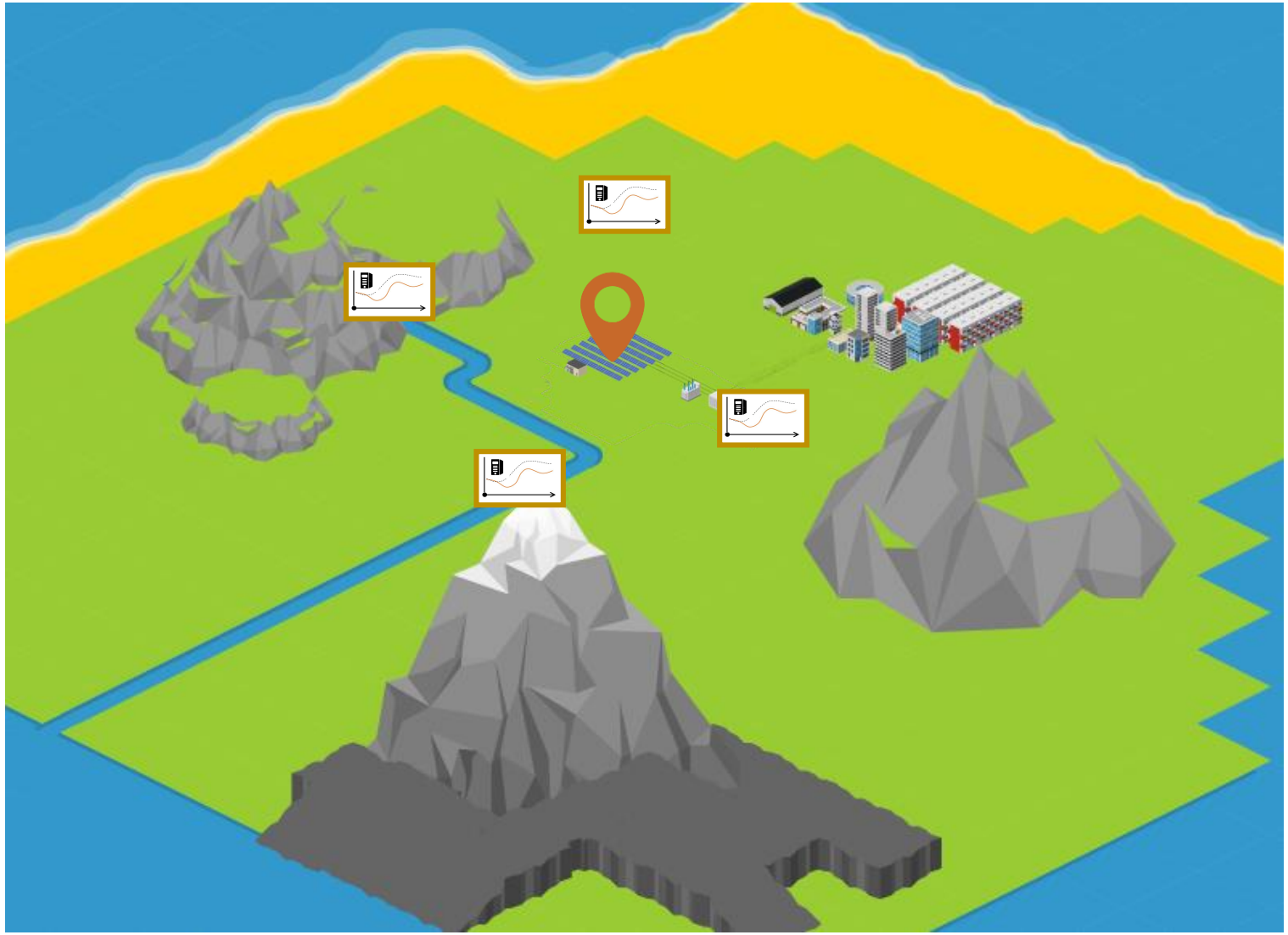
- One unique simulation
- « Quick » **calculation times**
- Finer spatial resolution

Spatial resolution on the island of La Réunion :



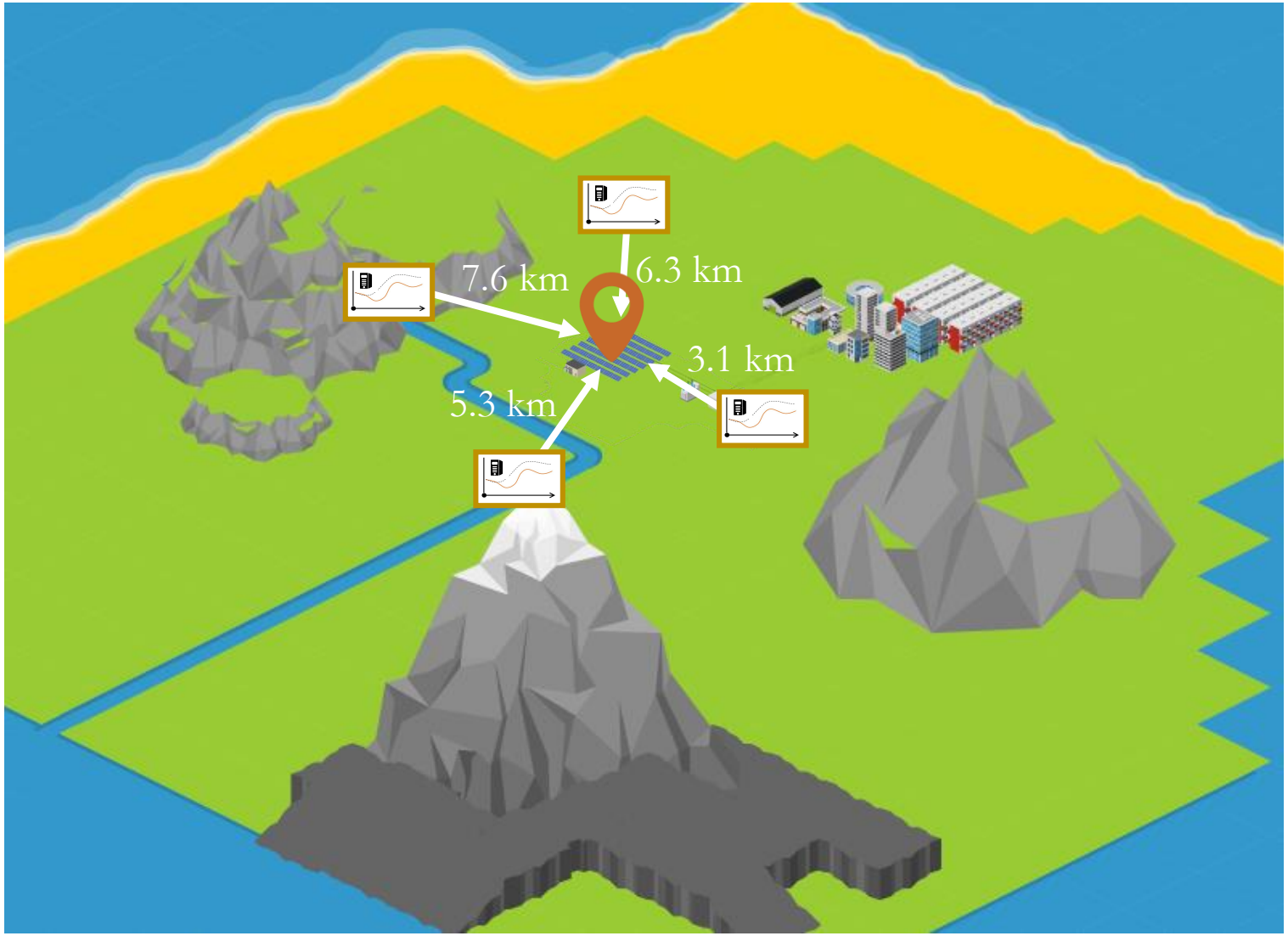
Applications for energy systems management

Building probabilistic forecasts



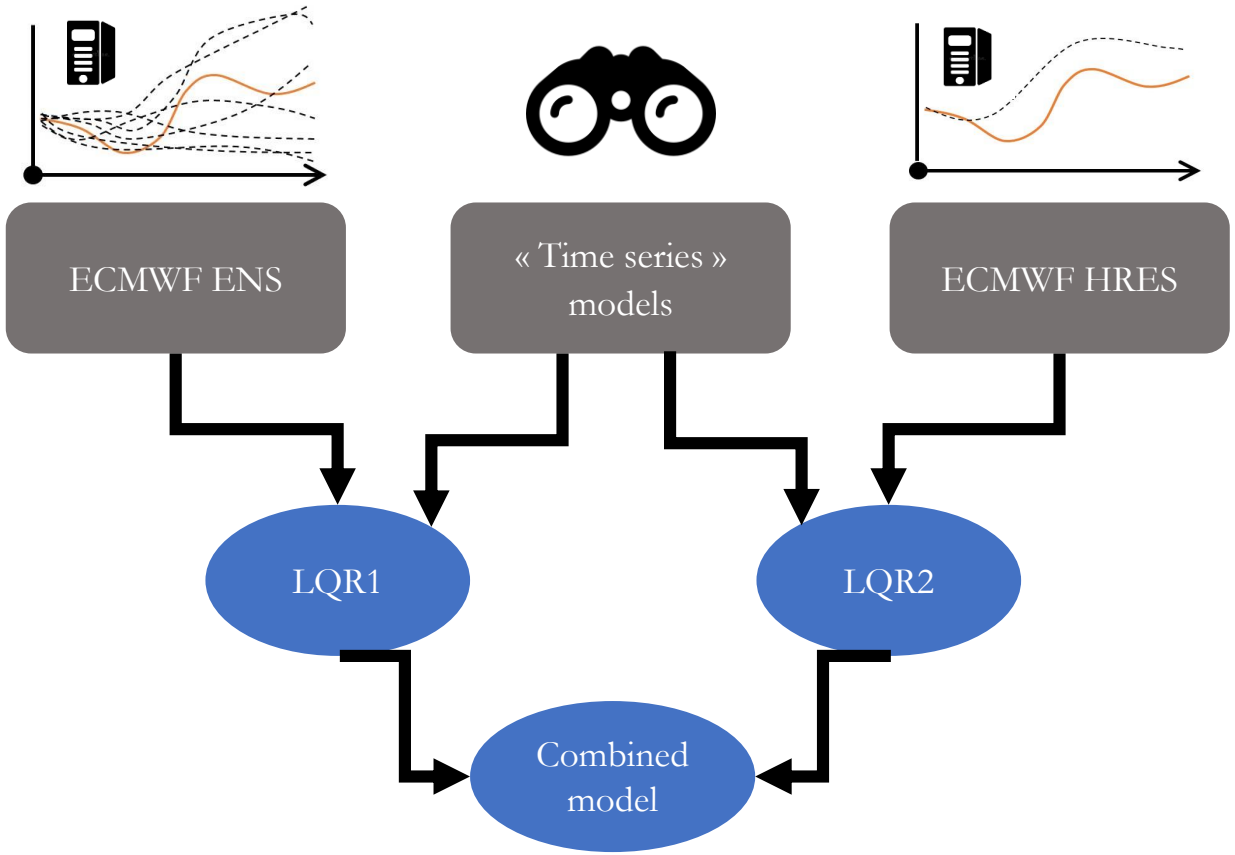
Applications for energy systems management

Building probabilistic forecasts



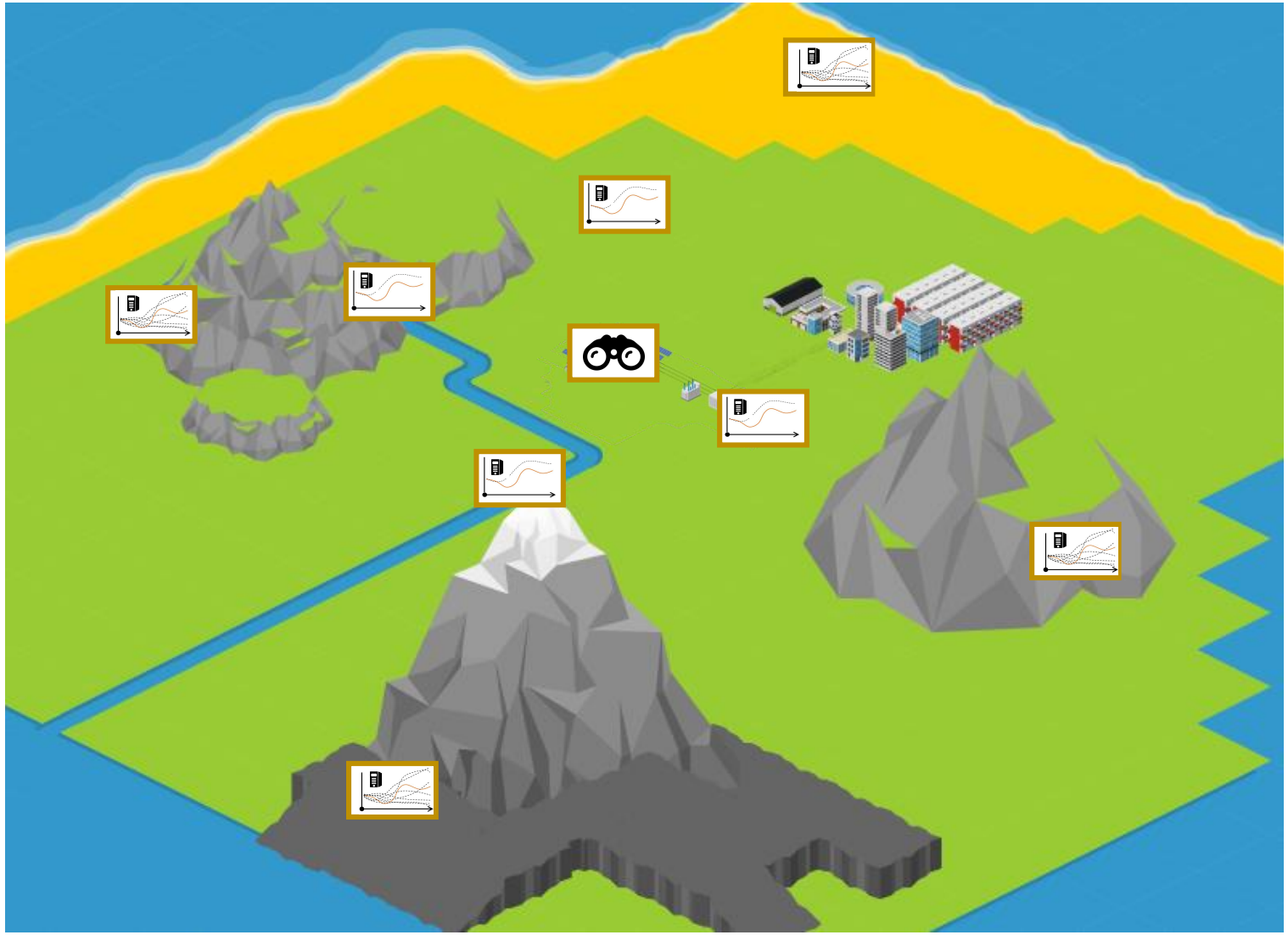
Applications for energy systems management

Building probabilistic forecasts



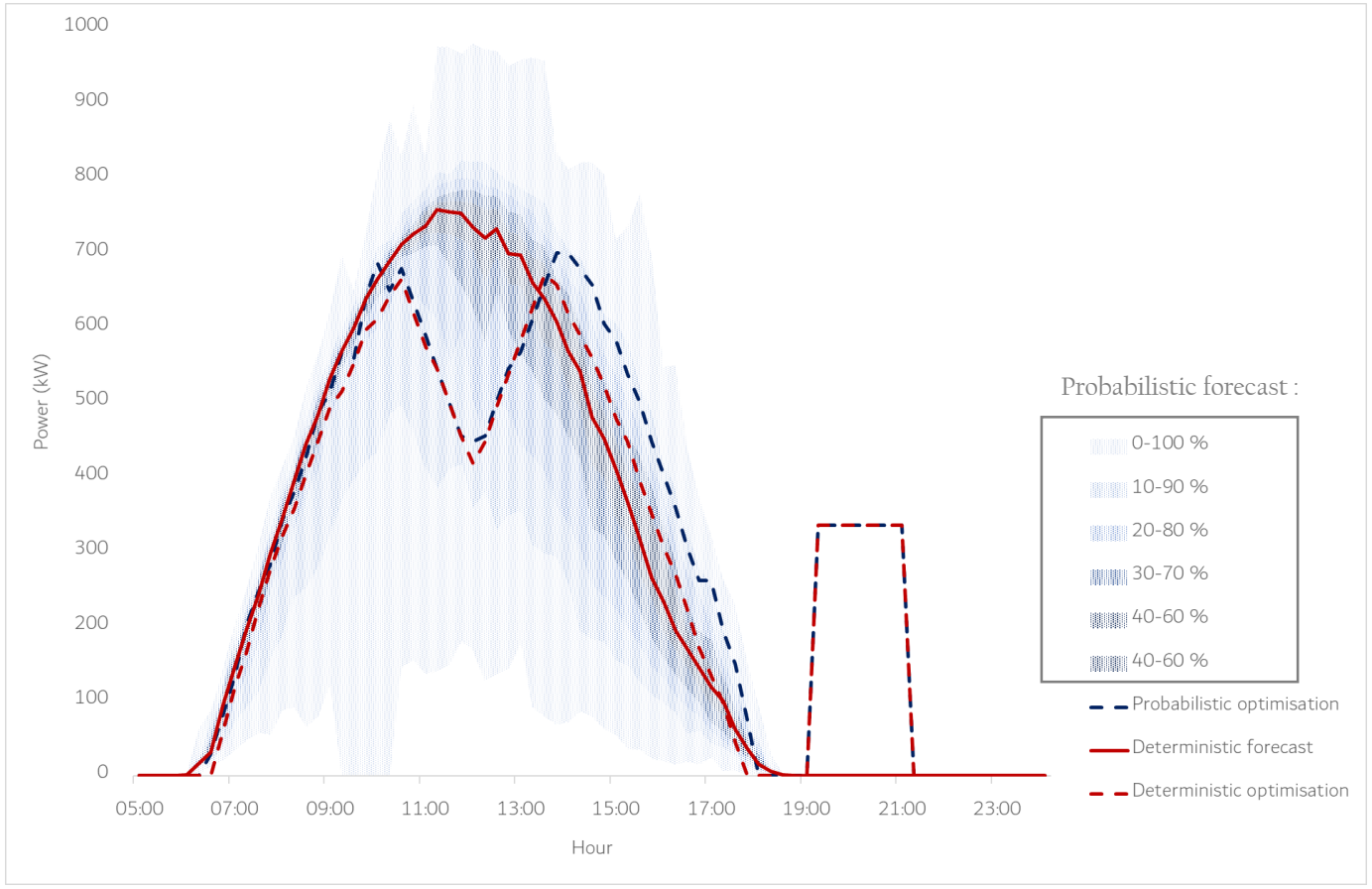
Applications for energy systems management

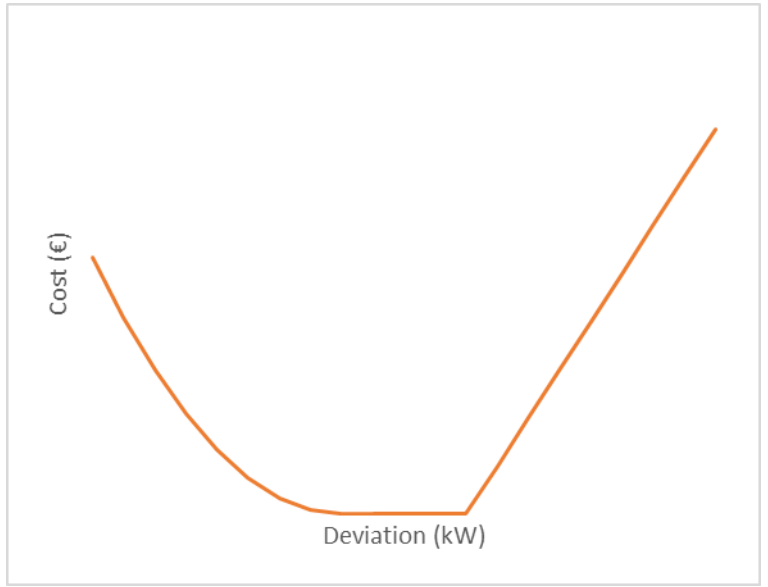
Building probabilistic forecasts



Applications for energy systems management

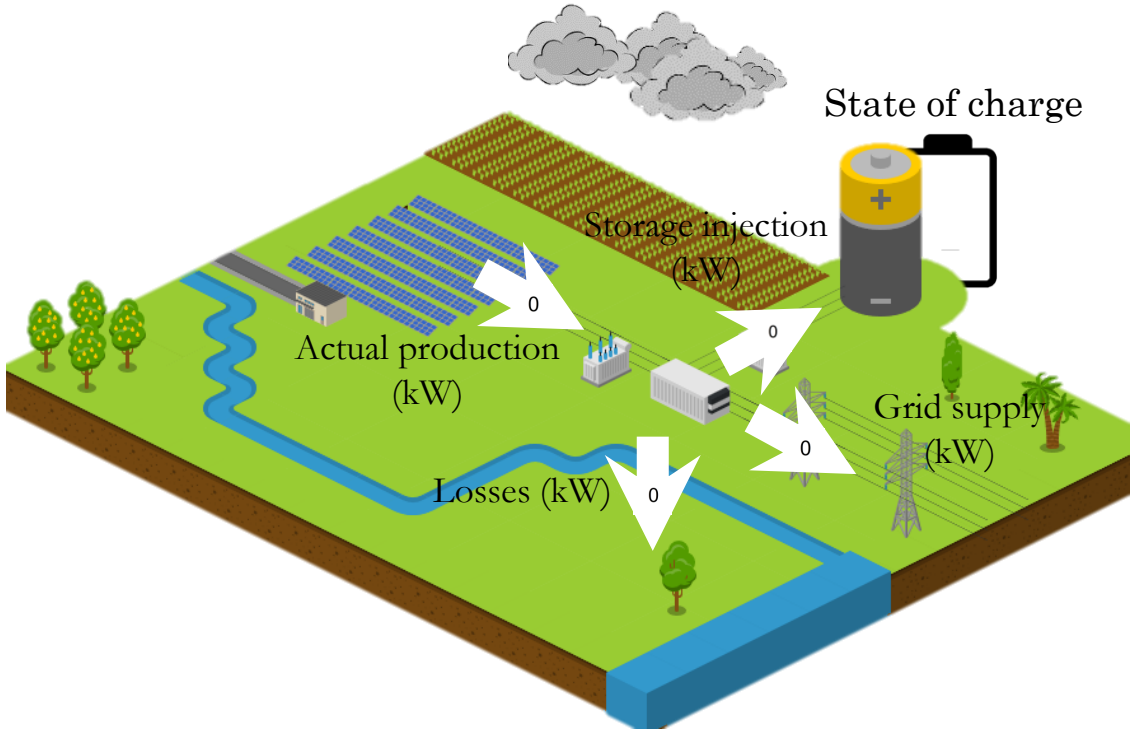
Deterministic versus probabilistic optimisation



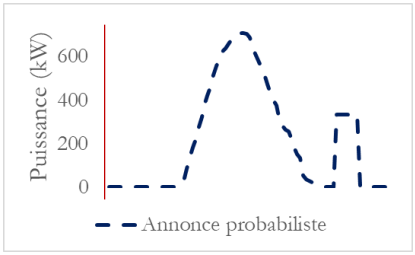


Applications for energy systems management

An exemple of probabilistic optimisation (2020/10/17 with LQR1 forecast)



Hour	Program (kW)
00:15	0

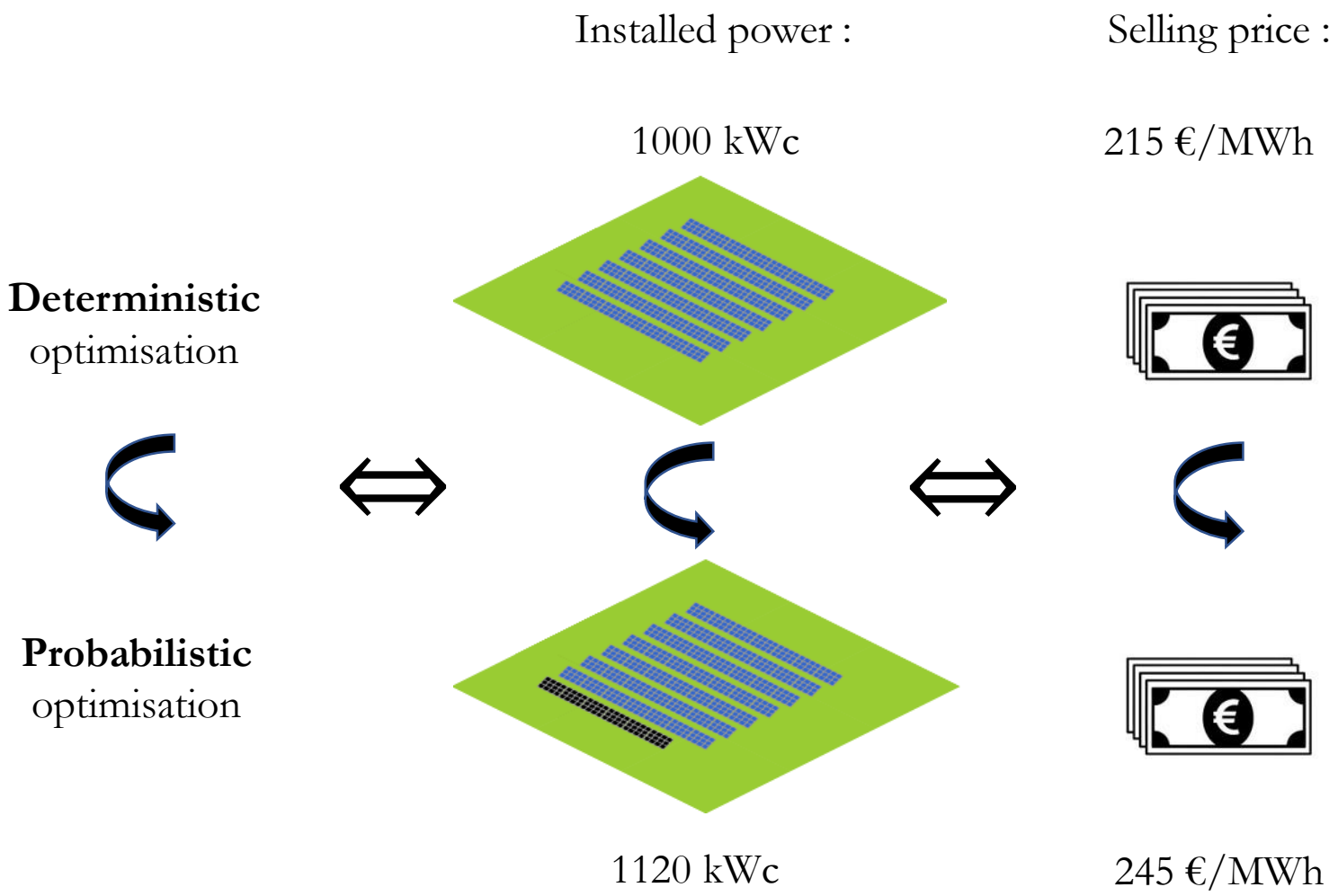


Economic indicators :

Income (€)	Penalty (€)	Net gain (cumul) (€)
0	0	0

Applications for energy systems management

The benefits of probabilistic optimisation



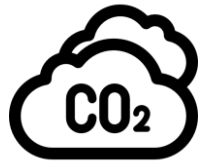
Applications for energy systems management

The benefits of probabilistic optimisation

Land use :

CO2 Emission :

Deterministic optimisation

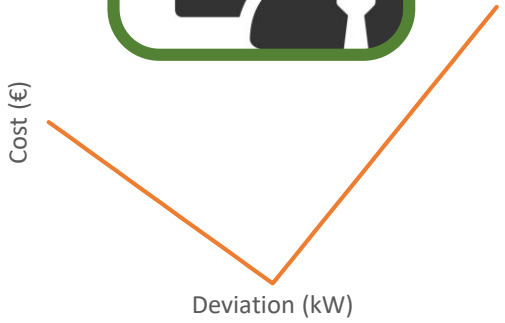


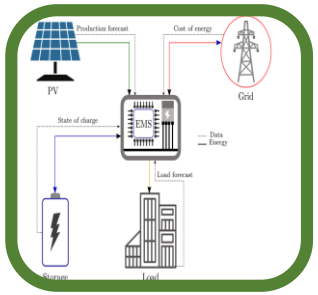
Probabilistic optimisation

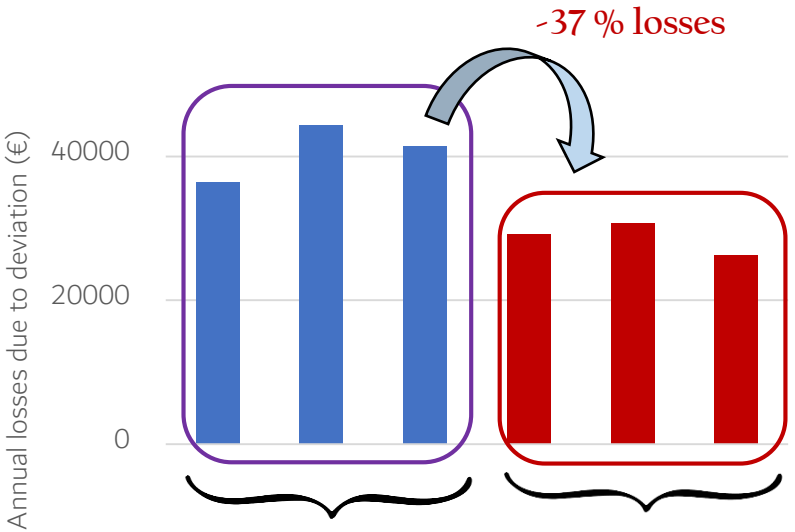
-1200 m²

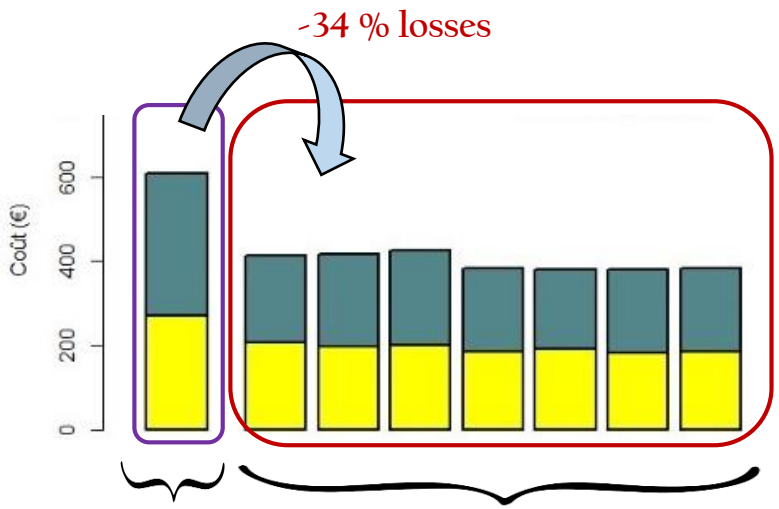
-112 t/year

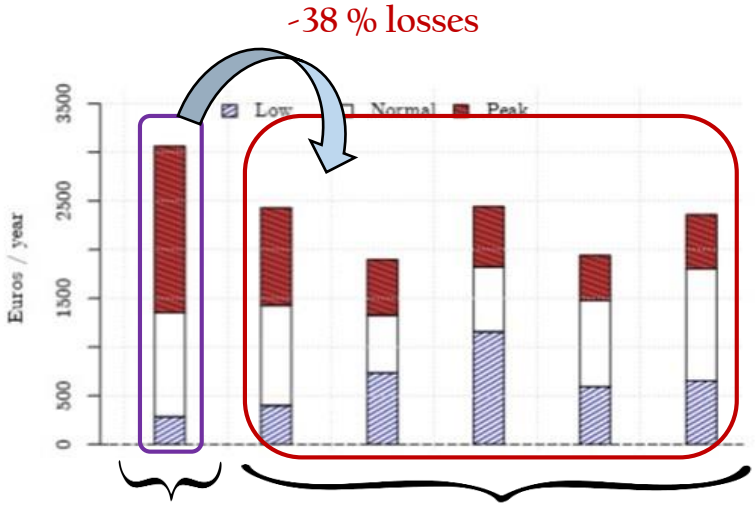
Applications for energy systems management





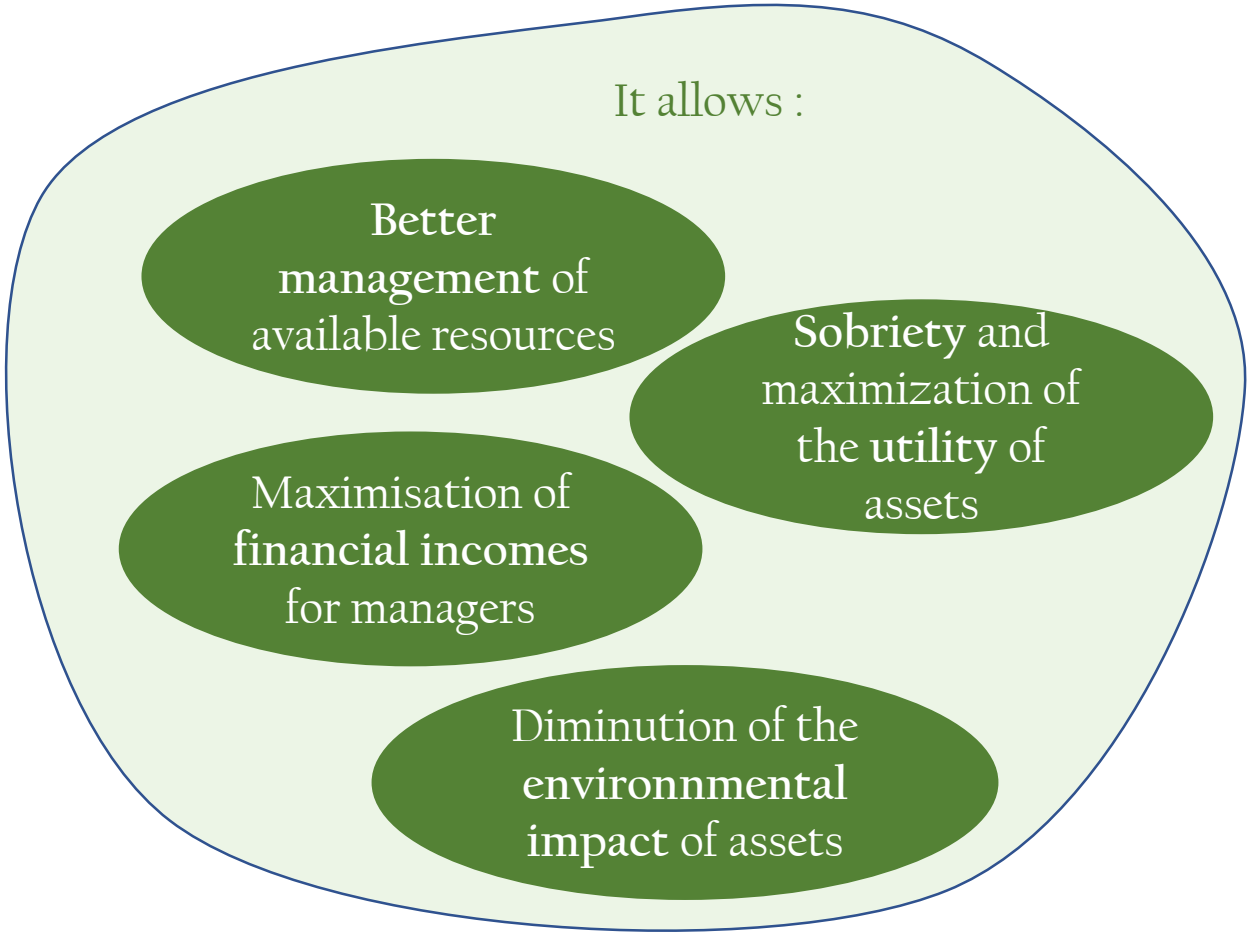


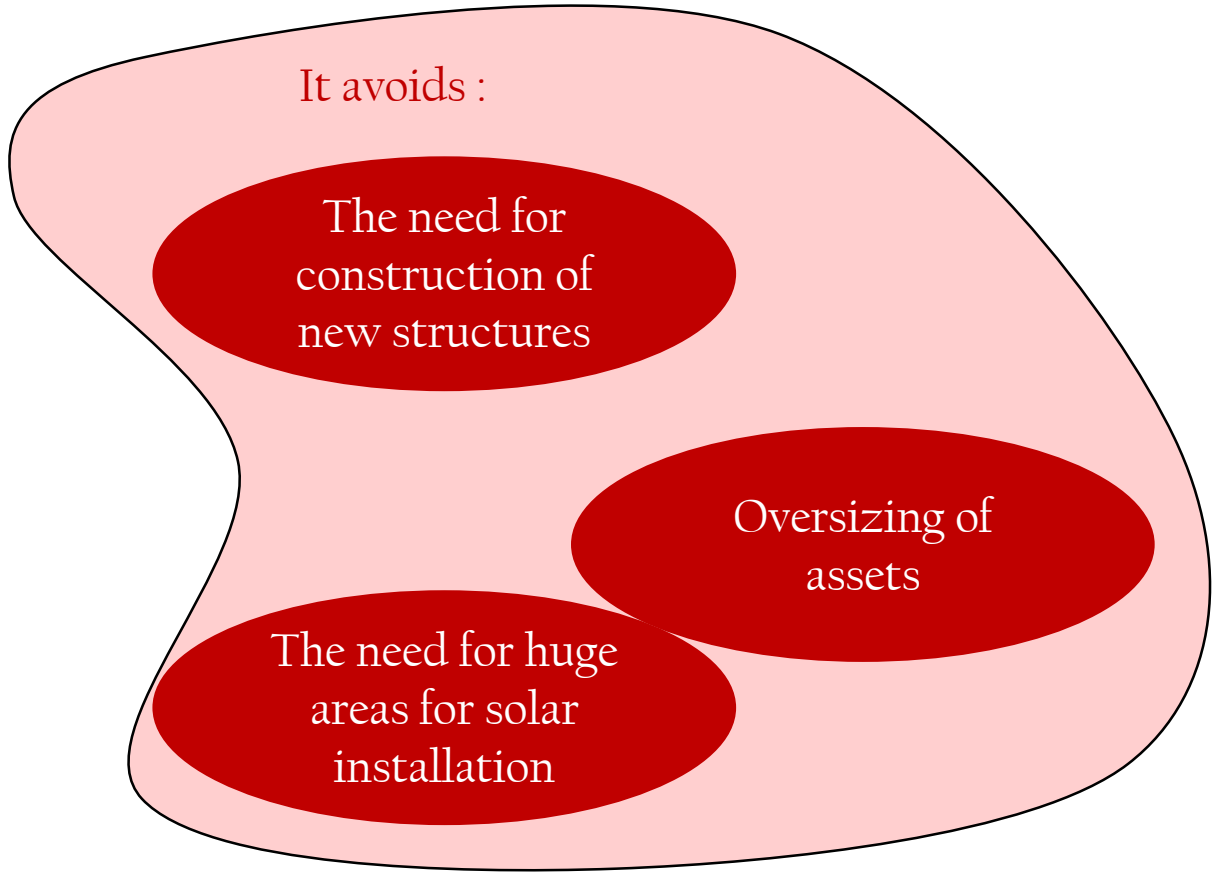


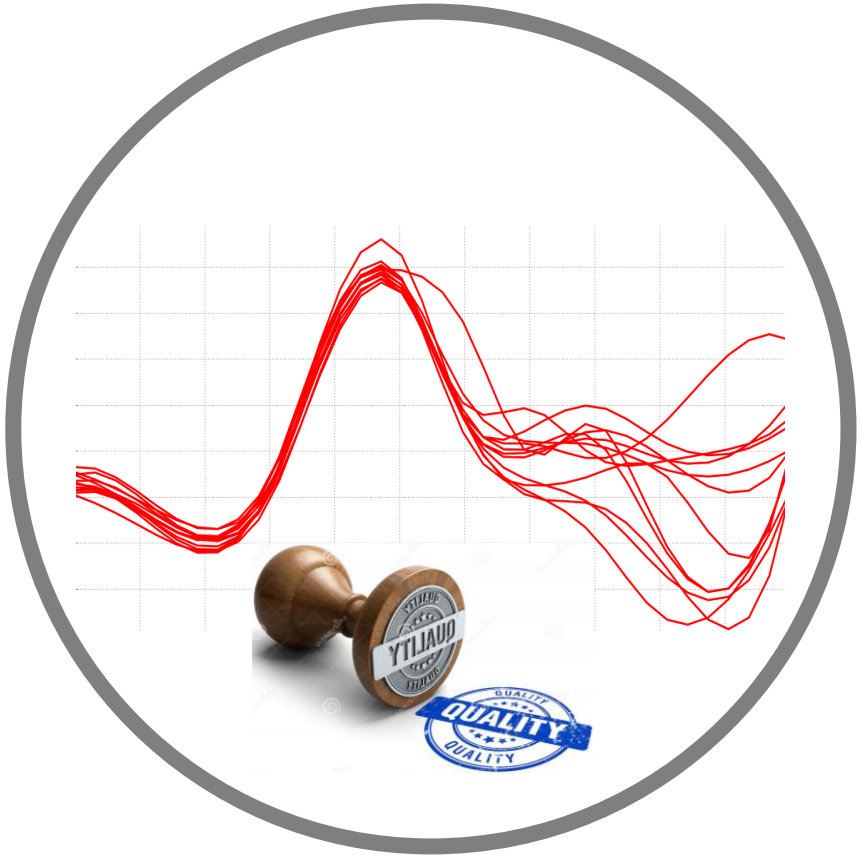


Applications for energy systems management

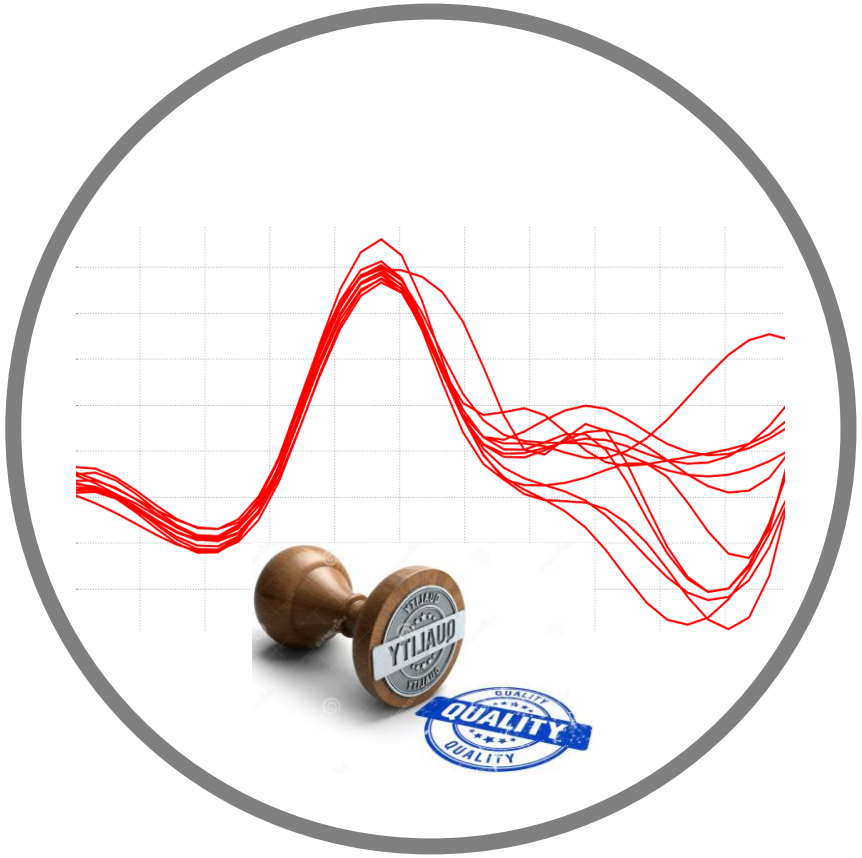
Why using probabilistic forecasting and probabilistic optimisation ?






QUALITY
QUALITY

The quality of probabilistic forecasts



Evaluation of the quality of probabilistic forecasts

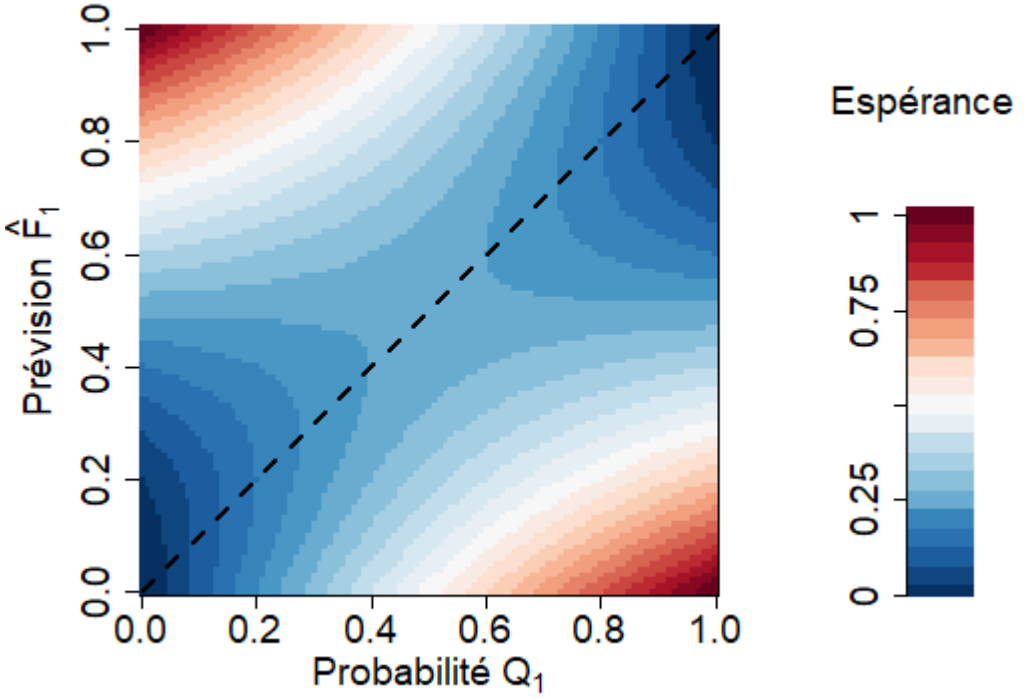
The Brier score

Negatively oriented score !!

$$Brier\ Score = (\hat{F} - o)^2$$

$$\mathbb{E}_{BS}(\hat{F}_1, Q_1) = Q_1(1 - \hat{F}_1)^2 + (1 - Q_1)\hat{F}_1{}^2$$

$$\forall Q_1, \min_{\hat{F}_1} \mathbb{E}_{BS}(\hat{F}_1, Q_1) = \mathbb{E}_{BS}(Q_1, Q_1)$$



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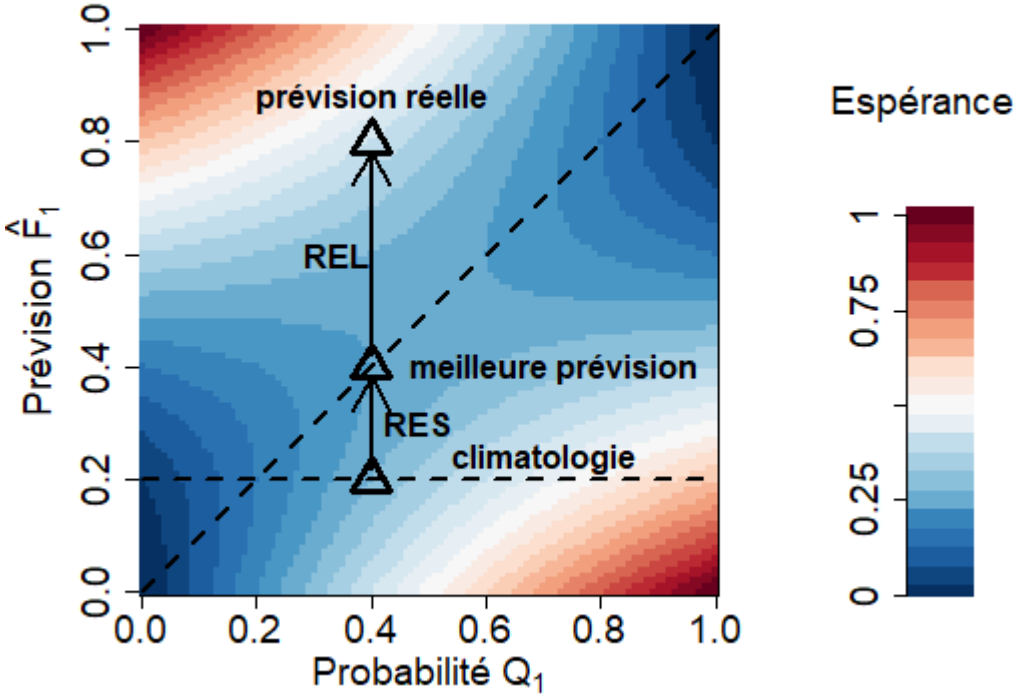
$$\mathbb{E}_{BS}(\hat{F}_1, Q_1) - \mathbb{E}_{BS}(Q_1, Q_1) = D\,(\hat{F}_1, Q_1)$$

$$\mathbb{E}_{BS}(\hat{F}_1, Q_1) = \mathbb{E}_{BS}(\bar{O}, Q_1) \quad - \quad D\,(\bar{O}, \hat{F}_1) \quad + \quad D\,(\hat{F}_1, Q_1)$$

Uncertainty — Resolution (≥ 0) — Reliability (≥ 0)



Thank you for your attention !

Any comment, recommendation, question ?

Don’t hesitate to come and discuss or to write at josselin.le-gal-la-salle@univ-reunion.fr